Performance Evaluation of Evaporated Water In Cooling Towers

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ABSTRACT

The cooling towers are an essential component of air conditioning plant. Cooling towers are used to dissipate heat from power plants, water-cooled refrigeration and industrial processes. When the humidity is more in the atmosphere, more quantity of water is required for cooling . When humidity is less in atmosphere, less quantity of water is required for cooling. The Cooling tower is very useful in industrial and residential area. The cooling tower is suffering from water losses like evaporation loss and drift loss. Due to which the make-up water quantity required for cooling tower is more. Therefore we have to use drift eliminators in cooling towers in order to minimize water loss from the system. Finally, to optimize the efficiency and the thermal performance of the cooling tower drift eliminator is proposed.

Keywords: *- Cooling Tower, Drift Eliminator, Fan, Fins, Water Evaporation, Drift Loss.*

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1. INTRODUCTION

Cooling tower can be used by many industries. The main function of a cooling tower is to reject heat into the atmosphere. They shows a comparatively inexpensive and dependable means of removing low-grade heat from cooling water. Hot water is return to the cooling tower from heat exchangers. The water from the cooling tower is sent back to the system like compressors. In industrial processes, the heat is descipitate to the environment to maintain operating conditions within the design limits. Cooling towers working principle is based on mass and heat transfer using direct contact between ambient air and hot water. Cooling towers require distribution or sprinkling water over a heat transfer surface across or through which a stream of air passes. As a result, the water droplets are incorporated in airstreams. This is called as drift and it is independent of water evaporation loss. So we have to use drift eliminators in cooling towers in order to reduce the water loss from the system. Drift eliminators changes the direction of the airflow as it passes through the eliminator so that most of the entrapped droplets are separated from the air stream and return to the tank. Due to the presence of the drift eliminator it affects two aspects of cooling towers their thermal performance and the amount of water drift loss.[1] The drift eliminator's performance depends on two factors: On the one hand, the droplet collection efficiency and, on the other, the pressure drop across the eliminator.[1]Numerical technique can be develop for a drift eliminator to setting for pressure drop limit and then choosing the geometry that provides the best collection efficiency. The cooling towers normally contain a wetted medium called "fill" to control evaporation by providing a large surface area. Cooling towers can be classified by the type of heat transfer; the type of draft and location of the draft, relative to the heat transfer medium; the relative direction of air and water contact and the type of water distribution system.

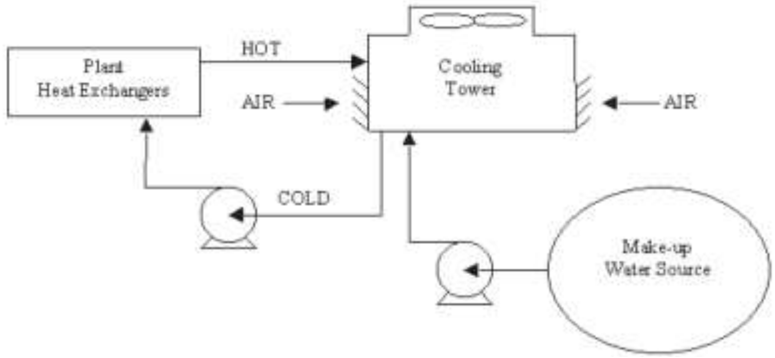

Fig -1: Cooling Water System

Cooling towers can be categorized by the movement of air and water as counter-flow and cross-flow types. Cooling tower has two types mechanical draft and natural draft. A cooling tower is a semi closed system for evaporative cooling of water by contact with air. The main function of cooling tower is to remove waste heat. Airflow direction is to some angle of water flow in cross flow cooling tower whereas opposite direction in counter flow cooling tower.

2. LITERATURE REVIEW

M. Lucas , P.J. Martinez , A. Viedma, this thesis studies the experimental determination of drift loss from a cooling Tower. The existence of cooling towers arises from the need to evacuate power to the environment from engines, refrigeration equipment and industrial processes.. The main objective of this paper was the experimental determination of drift loss from a cooling tower without drift eliminators and fitted with six different drift eliminators. They developed a numerical technique to design a drift eliminator for a particular cooling tower by setting a pressure drop limit and then choosing the geometry that released less water.

P.Balashanmugam, G.Balasubramanian, the thesis gives experimental study on the design of a cooling tower for a central air-conditioning plant. . Based on the trails conducted some of the points are found that have been influencing the cooling capacity of cooling tower. They are air velocity and temperatures drop across the fins. Both of them are directly proportional to each other. From trails it was found that the air flow velocity was poor in cooling, this is because obstruction in the air flow across the first due to algae formation in the fins.

Ghassem Heidarinejad , Maryam Karami, Shahram Delfani, the thesis gives numerical simulation of counter-flow wet-cooling towers. . It is demonstrated through a case study that it is important to include the spray and rain zones in analyses for a greater accuracy in design as well as rating calculations.

Chang Sub Kim , Melany Hunt , Jim Cowell, John Onderdonk, Matthew Berbee, they work on increasing cooling tower water efficiency. In this water efficiency Project, the amount of water loss due to evaporation and blowdown each month has been studied. . This project aims to improve overall water efficiency of cooling towers by examining two applicable systems that can recover vapor and reduce blowdown. An ozone treatment reduces the use of chemicals and thus decreases the blowdown rate.

Pushpa B. S, Vasant Vaze, P. T. Nimbalkar, they studied the performance evaluation of cooling tower in thermal power plant. An evaporative cooling tower is a heat exchanger where transformation of heat takes place from circulating water to the atmosphere.

Bilal Ahmed Qureshi, Syed M. Zubair, they performed a unified approach to predict evaporation losses in evaporative heat exchangers. Accurately predicting evaporation losses is significant since water, in this class of heat exchangers, is cooled primarily by evaporation of a portion of the circulating water that causes the concentration of impurities to increase.

3. COOLING TOWER

Two types of cooling towers i.e. Natural draft and Mechanical draft. Due to the large size of these towers, they are generally used for water flow rates above 45,000 m3/hr[2]These types of towers are used only by utility power stations. Mechanical draft towers uses large fans to force or suck air through circulated water. The water falls downward over fins surfaces, which increases the contact time between the air and the water this maximize the heat transfer between the two. The Cooling rates of Mechanical draft towers are depend upon their fan diameter and speed of the operation. The mechanical draft cooling towers are more widely used. Mechanical draft towers are available in the following airflow arrangements:

1. Counter flows induced draft.

2. Counter flow forced draft.

3.Cross flow induced draft.[2]

In the counter flow induced draft type, hot water enters at the top, while the air from the bottom and exits at the top. Both forced and induced type draft fans are used. In cross flow induced draft towers, the water enters at the top and passes over the fins. An induced draft fan draws the air across the wetted fins and leave it from the top. Mechanical draft towers are present in a large range of capacities. Normal capacities range from approximately 10 tons, 2.5 m3/hr flow to several thousand tons .Therefore, many cooling towers are assemblies of two or more individual cooling towers or "cells." Multiple-cell towers can be square or round depending upon the shape of the individual cells and also the air inlets are located on the sides or bottoms of the cells.

3.1 Principle Of Cooling Tower

The difference between the vapour pressure at liquid surface is the rate of evaporation from a wet surface .i.e vapor pressure and saturation pressure in the surrounding air, by the total pressure and absolute humidity of air remaining is determined. The remaining is determined by the total pressure of the air and its absolute humidity. In an enclosed space, evaporation can continue until two vapor pressure are equal, i.e. until the air is saturated and at the same temperature as the surface. However, if unsaturated air is constantly circulated, the wet surface will reach an equilibrium temperature at which the cooling effect due to the evaporation is equal to the heat transfer to the liquid by conduction and convection from the air, which under these conditions will be at a higher temperature. The equilibrium temperature reached by the surface under adiabatic conditions (i.e. in the absence of external heat gains or losses), is the wet bulb temperature‖.[2] In a cooling tower of very large size and with an adequate air flow, the leaving water will be at the wet bulb temperature of the incoming air. Because of this the difference between the temperature of the leaving water and the local wet bulb temperature is the effectiveness of the cooling tower.

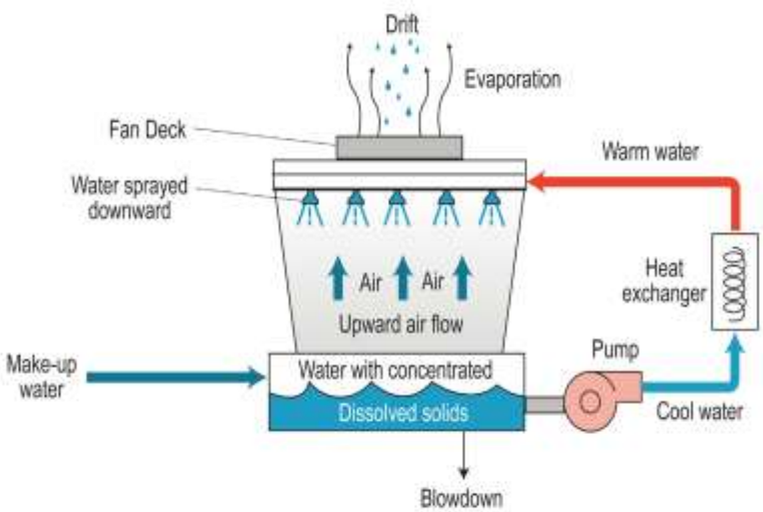

Fig -2: Principle of cooling tower

3.2 Air Temperature

Evaporation rate is affected by air flow. If the fresh air is flowing through the cooling tower then there is less concentration of contaminated air so there is more evaporation taken place. If there is high concentration of other substances then it will affects on evaporation rate so there is less evaporation rate .Evaporation mainly depends on temperature of air . If air temperature is high then evaporation is faster otherwise there is less evaporation due to low temperature of air. So the air temperature is inversely proportional to the rate of heat loss.[6]

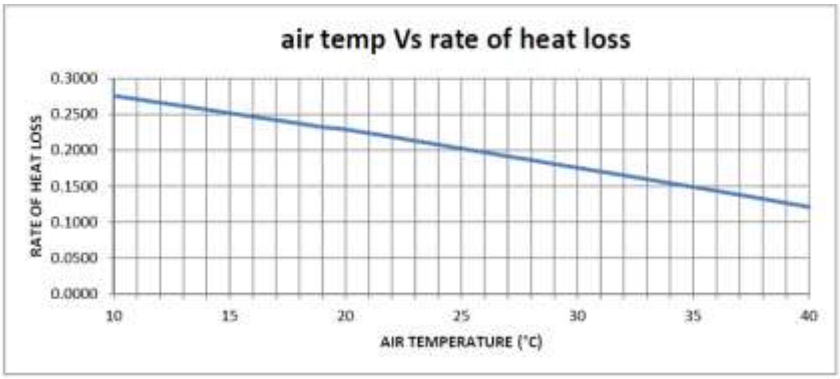

Fig-3

3.3 Relative Humidity

Humidity is defined as the amount of water vapour present in the air. The relative humidity of an air-water mixture is defined as the ratio of the partial pressure of water vapour in the mixture to the saturated vapour pressure at a given temperature. Therefore the relative humidity of air is a function of both temperature and water content. Relative humidity is generally expressed as a percentage. The wet bulb thermometer has wet cloth on its bulb, air is passed over it, the water evaporates, and the temperature is recorded. Most of the time the two thermometers will have different temperature readings, however, if the air is completely saturated with water the readings will be the same.[6] When 100% relative humidity is reached, the air cannot accept the water, the water on the bulb cannot evaporate, and the temperature is equal to the dry bulb. i.e. if the wet bulb temperature is lower, the humidity is lower. From the graph it is clear that, as the relative humidity is increasing, the rate of heat loss is gradually reducing as the air is getting saturated.[6]

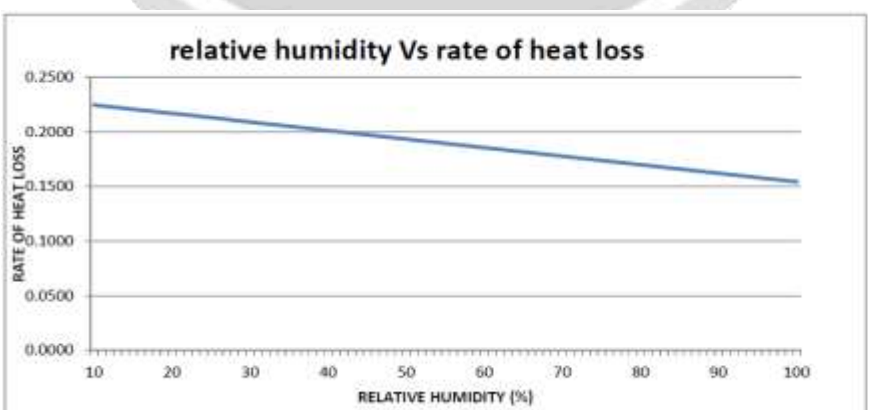

Fig -4

3.4 Water Temperature

If the water is at atmospheric temperature, the rate of heat loss will be normal. However, as the temperature of water is increased gradually, the rate of heat loss will gradually increase. The temperature of the water also has an effect on the evaporation rate. Because, the hot water contains more energy than cold water. Water evaporates at quick rate as the boiling point is reached. The temperature of the water gives the idea about, how energetic the water molecules are. If the molecules are more energetic, the more likely they are to break free from the liquid and get into the air. Therefore water temperature is directly proportional to rate of heat loss.

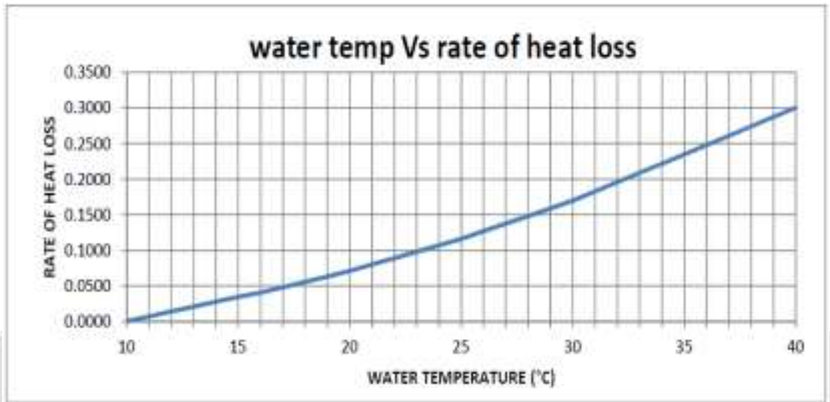

Fig -5

3.5 Wind Velocity

Evaporation rate increases with increases wind velocity. The reason is that, if the air is perfectly still, the air become saturated near to any moisture source , and unable to take up any more moisture. Because the air is not moving, this means that no more moisture would be able to be absorbed. If the air is in motion, then the air moisture is replaced by less saturated air, which can take up more moisture and is then replaced. If there is enough motion to replace the saturated air with fresh less saturated air, then the evaporation rate will stay pretty much the same. Thus, the faster the wind speed, the faster is the evaporation rate. This can be experienced when we use a blow dryer or a hand dryer in bathrooms. In cooling tower the entire process is taking place in a close environment. It means the natural wind will not be taking part in the process of cooling.[6] However as the water droplets are falling under the gravity and air particles move upward under density currents, the wind action is generated. It also becomes warm and moves up in the tower and the process continues

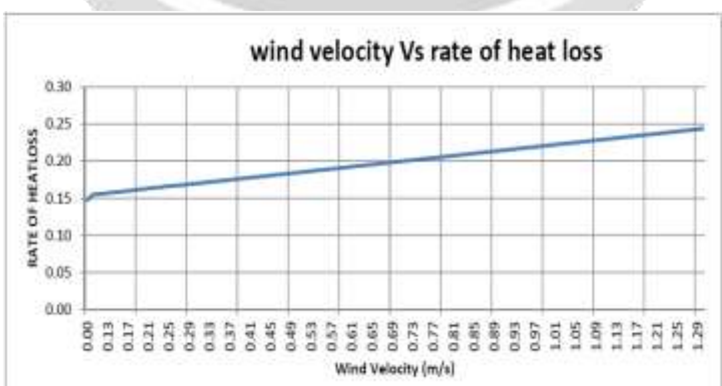

Fig -6

4. FORMULAE

Evaporation Losses in m3/hr = 0.00085 x 1.8 x circulation rate(m3/hr) x (T1-T2)

Percentage Evaporation Loss= (evaporation loss / circulation Rate)*100

5. DRIFT ELIMINATOR

Drift Eliminator is the equipment placed at the discharge side of the cooling tower structure for reduction of drift loss. Drift eliminator cooling towers are vacuum-formed PVC film assemblies and designed with multiple zigzag passes. Drift Eliminators are result of extensive research and testing using state of the art technology to solve a universal cooling tower problem in the most cost effective way. The pressure loss of the air stream flowing through an eliminator is an important factor in designing a drift eliminator. A large pressure drop will reduce the tower cooling capacity which will increases the capital cost or the operating cost of the tower. An estimate reveals that a flow resistance of three velocity heads will increase the final temperature of the condensate by approximately 0.20C. This seems to be a very small increase, yet it is significant in terms of overall station economics, bearing in mind that 10C is valued at about $3M over the life of a 2000MW station. The flow resistances of current industrial drift eliminators range from two to ten velocity head.[8]

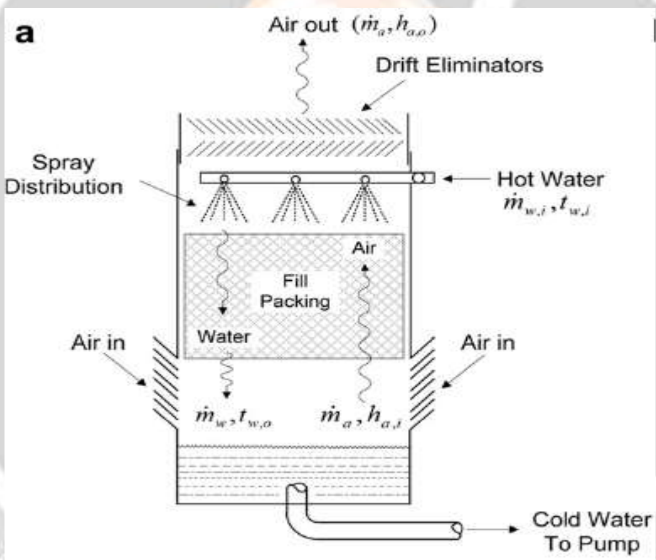

Fig -7: Cooling tower with Drift eliminator

5.1 How Do Drift Eliminators Work

- The Blade and cellular design works by inertial impaction.
- The wall of drift eliminator is impact by heavy droplet’s inertia.
- The Cellular type of drift eliminator is efficient due to more surface for droplet impaction.
- A water film is form by Collected droplets and drain down.

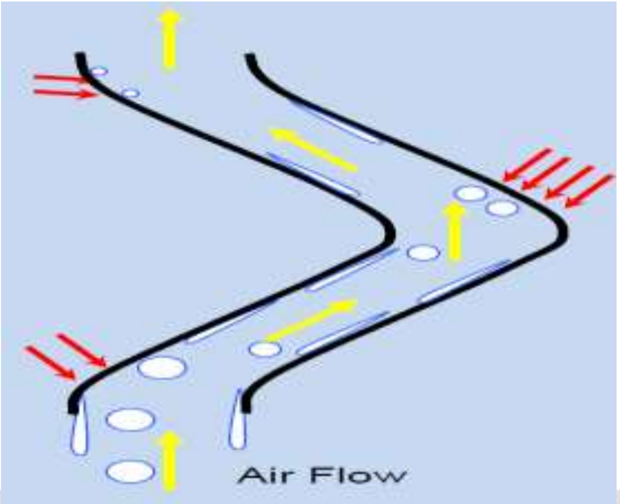

Fig-8: Air flow diagram

6. DATA RECORDER

Time	Day 1 (depth in cm)	Day2 (depth in cm)	Day 3 (depth in cm)
8 to 9	8	8.1	8.1
9 to 10	8.1	8.1	8.1
10 to 11	8.1	8.1	8.1
11 to 12	8.1	8.1	8.1
12 to 1	8.2	8.2	8.1
1 to 2	8.2	8.2	8.2
2 to 3	8.1	8.2	8.1
3 to 4	8.1	8.1	8.1

Table -1: Readings without drift eliminator

Time	Day 4 (depth in cm)	Day 5 (depth in cm)	Day 6 (depth in cm)
8 to 9	7.9	7.9	8
9 to 10	7.9	7.9	8
10 to 11	7.9	8	8
11 to 12	8	8	8.1
12 to 1	8	8	8.1
1 to 2	8	8	8
2 to 3	8	8	8
3 to 4	8	7.9	8

Table -2: Readings with drift eliminator

7. CHARTS

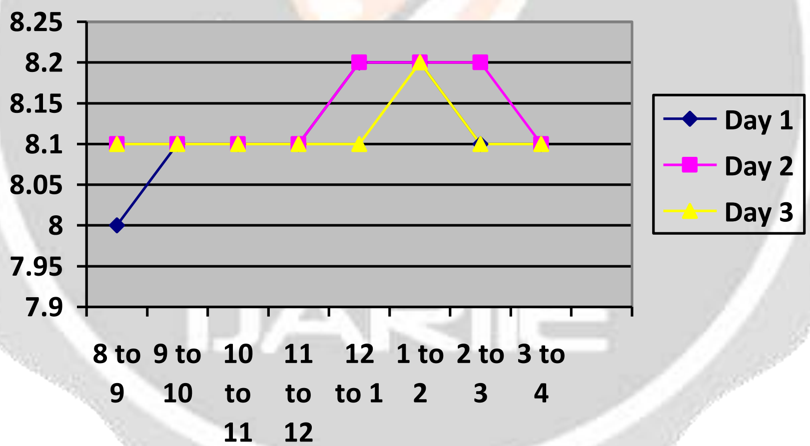

Chart -1.depth in cm Vs time in hours

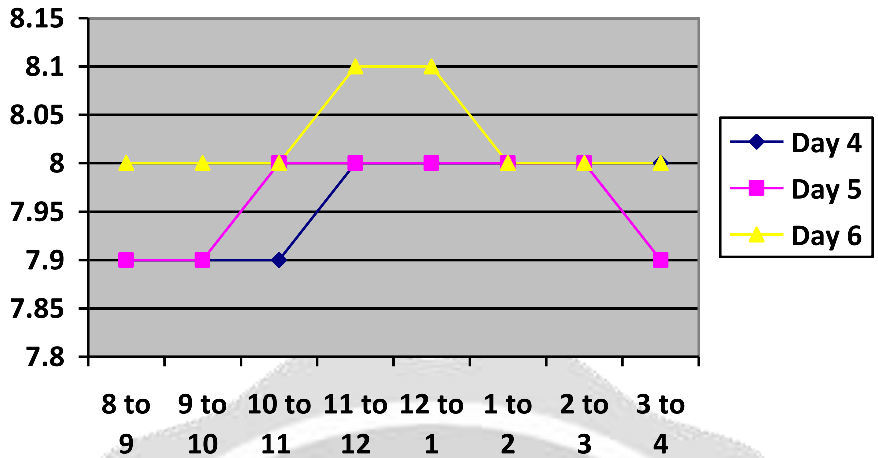

Chart -2.depth in cm Vs time in hours

8. SPECIFICATION

1. Pump input =156kw
2. Total head of pump =50m
3. speed of motor =1400rpm
4. Inlet Cooling Water Temperature °C = 41.5
5. Outlet Cooling Water Temperature °C = 30
6. CT Water Flow/Cell, m3/hr = 400 m3/hr
7. CT Range= (41.5-30) °C=11.5°C
8. Evaporation Losses in m3/hr = 0.00085 x 1.8 x circulation rate (m3/hr) x (T1-T2)
   = 0.00085 x 1.8 x 400 x (41.5-30) = 7.038m3/hr

9. CALCULATIONS

Dimension of tank =Length x Breadth x Height
=1000cm x 500cm x250cm
=10m x 5m x 2.5m

Volume of tank =10 x 5 x 2.5=125m3=125000litre

Evaporation loss of water without used of Drift Eliminator:
= 125-[(10-0.081) x (5-0.081) x (2.5-0.081)]
= 125-118.0267
= 6.973m3/hr= 6973litre/hr

Evaporation loss of water with used of Drift Eliminator
= 125-[(10-0.08) x (5-0.08) x (2.5-0.08)]
= 125-118.1114
= 6.8886m3/hr
= 6888.6litre/hr

Water saves by used of Drift Eliminator:

= (6973-6888.6)
= 84.4litre/hr

= 84.4 x 24litre/day
= 2025.6litre/day

10. CONCLUSION

The drift eliminator mainly affects two parameters of cooling towers: their thermal performance and the amount of water drift loss. The first observation made is that the level of drift, when drift eliminator is not installed, is very substantial. It is important to note that the drift values achieved by an eliminator are restricted to operating conditions .i.e drift is not a property of drift eliminator, but the amount of water emitted by a tower involves other elements such as the airflow distribution system, and fan inside the tower or filling. Drift eliminators reduces the drift loss from cooling towers i.e. condenses the water droplets in the air, back to the system without increase in energy used due to load.

11. REFERENCES

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